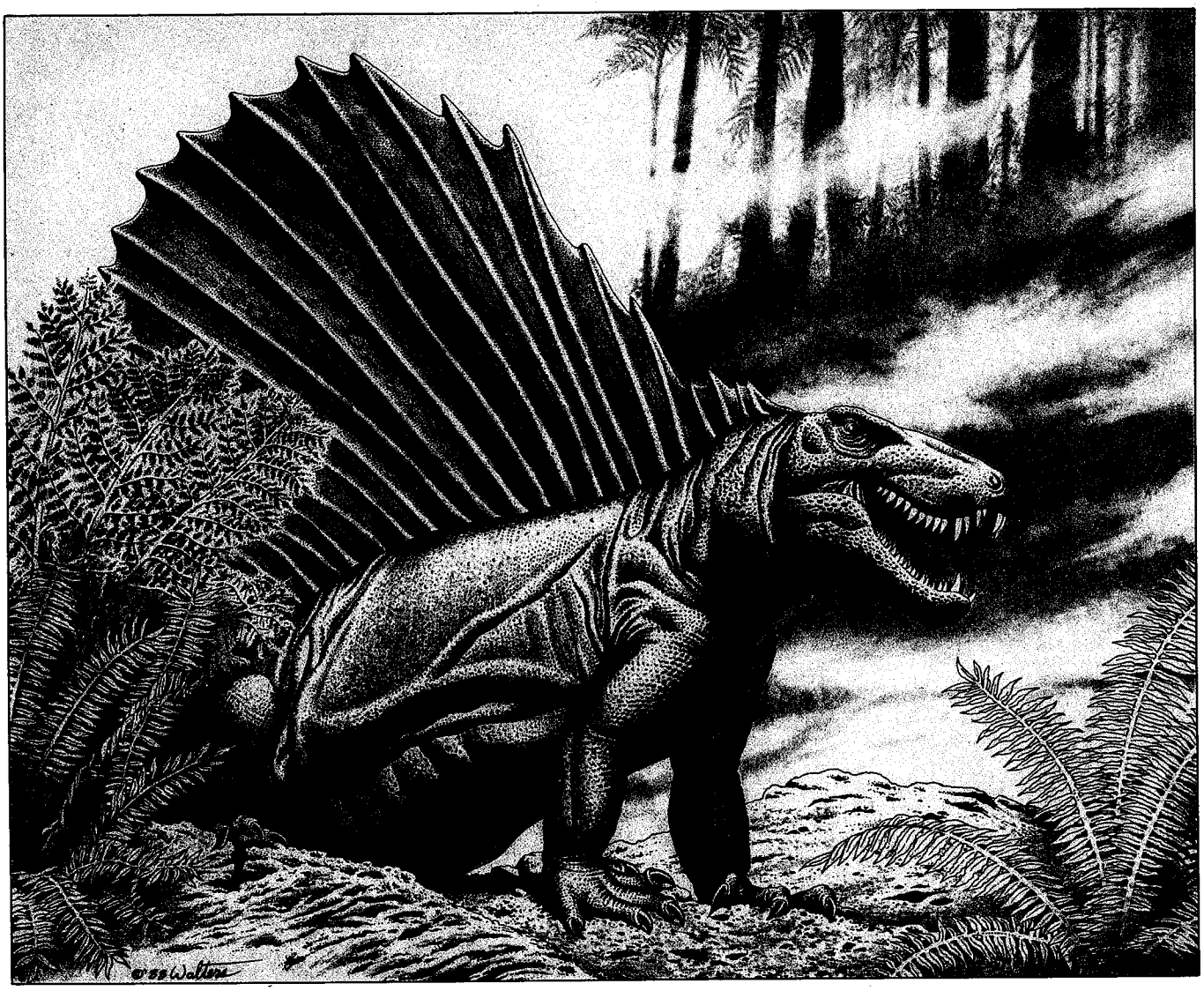
THE MOSASAUR



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The Mosasaur

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Quaternary Mammals from the Continental Shelf off New Jersey

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Abstract

New specimens dredged up from the continental shell off New Jersey are reported, and several taxa are recorded for the first time from the shelf in this area. While most specimens are representative of glacial-phase forms, there is a less common component of interglacial animals. A variety of taphonomic processes may be involved in concentrating remains of both terrestrial and marine forms in restricted areas of the continental shelf.

Introduction

From time to time clammers dredging the continental shelf off the East Coast have brought up interesting specimens of Pleistocene mammals (Whitmore et al., 1967; Richards, 1951, 1957, 1959). Often the data associated with these specimens are quite meager ("Off Cape May") and precise locations and depths are lost. Thus, very little can be said about the mode of occurrence of these specimens, other than that they were brought up from the shelf somewhere.

We report here some new specimens recently obtained from a single spatially restricted area on the continental shelf off New Jersey, and review the fauna now known from the shelf area. We also offer some comments on the nature of such occurrences. The Flandrian transgression that started with late Wisconsinan retreat of continental ice sheets and shrinking of alpine glaciers continues, offering us a model for marginal marine deposition of organic concentrations not only during the Quaternary, but for earlier periods as well.

Initial Discovery

On 5 March 1987, one of us (W.G.) as asked by Lynn Chase, a school teacher in Manahawken, New Jersey, to look at a suspected mastodon tusk at the home of Bub Giberson. The specimen was actually a walrus rostrum with both tusks intact. Also obtained from the same clam-bed during a separate dredge was a mastodon tooth complete with roots, one set of which was impacted. There were other assorted bones; according to Mr. Giberson, tusks, tooth, and bones all came from one spot approximately 24 miles east of Little Egg Inlet. They were obtained by clam boats operating out of Barney's Dock in Atlantic City, New Jersey. Mr. Giberson, dockmaster of the clamming fleet at this location, generously agreed to loan the specimens to

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Figure 1. The first specimens from the Barney's Dock site: on left, mastodon tooth; on right, walrus skull with tusks. Scale in centimeters on top, inches on botton.

the New Jersey State Museum for study and display. The walrus rostrum was found by Barney Truex, Jr.; the mastondon tooth was brought back by Charles T. Olley, Jr. (see Figure 1).

Subsequent Finds

On 10 March 1987, Mr. Giberson contacted the State Museum to notify us that more bones had been dredged up from the same spot. Some were described by the clammers as "joint bones with heads as big as half a basketball." Unfortunately, most of these were thrown back into the water, a probable fate of many such specimens. A walrus tusk was retained and this, too, was loaned to the State Museum.

Subsequent trips to the same spot produced more material, some of it quite interesting. A right dentary fragment from a subadult male mastodon has a large abcess below the alveoli; premature shedding of the teeth occurred, and the animal may have died of starvation or blood poisoning.

Another find confirmed a prediction. Bub Giberson asked one of us (W.G.) about what else the clamming crews might find. On the basis of onshore finds of Pleistocene animals, it was indicated that cervid antlers (*Cervalces* or *Rangifer*) might be brought up. Within a month, the same location that produced the walrus and mastodon remains yielded a portion of caribou antler. This is the first record known to us of *Rangifer tarandus* from the continental shelf.

Additional material includes whale vertebrae and skull fragments, a walrus lower jaw, a large teleost fish vertebra, and limb elements of marine mammals. Terrestrial and marine forms apparently occur together within a spatially restricted area. They presumably are all on the surface of the seafloor, since the bite of the clamming dredge is no deeper than three inches into the substratum. Some of the cetacean material is thoroughly blackened and permineralized, while other specimens are bone-white and virtually unalterred.

Location and Bathymetry

The precise location of the fossil concentration was given by the captain of the *Amanda Sue*, Daniel Loper, as 74°10'W., 39° N. The Loran readings are between E-W 42792-42797 and 26855-26857 N-S diagonals. The site is adjacent to a wreck indicated on the nautical chart. Material was obtained from a dredge-haul 15 m wide by 305 m long (50 ft x 1000 ft) on the side of a submerged drop-off from 36 m to 40 m (120 to 130 ft) deep. Matrix adhering to the original mastodon tooth brought up from the site is a silty grayish sand with abundant clam fragments.

Because of its discovery by the clamming vessels operating out of Barney's Dock in Atlantic City, we will refer to this particular continental shelf locality as the Barney's Dock site in this report.

Associated Invertebrates

An interesting feature of this occurrence is the close association of marine pelecypods with the vertebrate remains. The site is dredged for the surf clam *Spisula solidissimma*, or as it is commercially known, the chowder clam. Large individuals are taken to be processed into clam meat for soups and other uses. The initial mastodon tooth brought up still has abundant spat of *S. solidissimma* adhering to it. Apparently, the spat of *S. solidissimma* find this substrate an attractive environment for setting, so there is a population concentrated at this spot.

Some of the bones have borings in them, and in one case the culprit has been caught in the act. An intact pholad clam was found in a boring in a whale skull fragment from the Barney's Dock site. Pholads such as *Zirfaea crispata* and *Barnea truncata* are common hard-substrate borers found off the New Jersey coast. Since the whale skull fragment is not permineralized, it is relatively recent and it is likely that a modern borer is involved. The visible edge of the shell in the bore-hole is highly crenulated, as in forms such as *Z. crispata* or *B. truncata*.

SYSTEMATIC PALEONTOLOGY

We will not only describe the recently dredged material from the Barney's Dock site, but also specimens previously unreported, or mentioned only in passing without specific information about the specimen or its repository.

Abbreviations

ANSP	Academy of Natural Sciences of Philadelphia
NJSM	New Jersey State Museum, Trenton
PU	Princeton University (now at Peabody Museum, Yale University)
USNM	U.S. National Museum (Smithsonian Institution, National Museum of Natural History)

Order Rodentia
Family Castoridae
Genus *Castoroides*

Referred material: NJSM 12236, 13478.

The remains of the giant beaver are rare enough to warrant documentation of two recently discovered specimens, although they were recovered from a Monmouth County brook site rather than from offshore. Both teeth are referred to *C. ohioensis* Foster, and both are from Hop Brook in Holmdel, New Jersey. NJSM 12236 is a right upper second molar; NJSM 13478, found and donated by James Leggett, is an upper molar, probably the first right. Both specimens are from the fluvial facies of the Cape May Formation of Wisconsinan age.

The intriguing near associations of *Castoroides* with early humans continue to be found. Gerard R. Case, who found NJSM 12236, also found a fluted projectile point (NJSM 83-8.1) within one meter of it. The specimens were in an irrigation cut only recently excavated and were thus in close proximity to each other.

Order Carnivora
Family Phocidae
Phoca sp.

Referred material: NJSM 11887.

A phocid phalanx, apparently a second phanx from the pes, was dredged up from sediments of probable Pleistocene age at 38°25' N., 74°48' W. (approximately 15 mi. northeast of Ocean City, Maryland) in March, 1977, by Douglas Jones. Pleistocene seal remains are known from onshore deposits in Virginia (Ray et al., 1968) and Quebec (Harrington & Sergeant, 1972). We were unable to locate other shelf seal specimens, so this may be a new record.

Family Odobenidae
Genus *Odobenus*

Referred material: NJSM 10412, 11260, 11906, 12400; ANSP 15258, 15552, 15853, 15856; and material on loan to NJSM from Bub Giberson and Barney's Dock.

In 1860, Joseph Leidy described and figured the skull of a bull walrus found on the beach at Long Branch, New Jersey. This specimen apparently was obtained by Ward's Natural Science Establishment at some point, but was eventually accessioned as NJSM 10412. Dr. Clayton Ray recognized the specimen and called it to our attention.

During the 1950s, Horace Richards, then the Curator of Geology and Paleontology at the Academy of Natural Sciences of Philadelphia, obtained many specimens from clam dredgers operating out of Cape May, New Jersey (Richards, 1951, 1957, 1959). A number of these were walrus tusks, jaws, and portions of skulls. Many of these specimens have few locality data with them, although Richards (1957) noted that one exceptionally fine skull was dredged "from an old clam bed about 18 miles east of Wildwood." Another interesting exception to this lack of locality data is ANSP 15552, a mandible dredged from the Delaware River near Delair, Pennsauken Township, New Jersey (Parris, 1983).

The Larson family of Long Beach Island donated NJSM 12400, a skull portion with tusk remnants and six cheek teeth.

The specimens from the Barney's Dock site include a rostrum approximately 48 cm long with two tusks about 30 cm long. This was the first walrus specimen from this locality to be brought to our attention. Subsequent finds include two separate tusks, a mandible, and a possible humerus. These are referred to *O. rosmarus*, the modern walrus of Arctic waters.

Kardas (1965, 1968) thought that the fossil and subfossil specimens should be assigned to *O. obesus*, the old name for the Pacific population of *O. rosmarus*. Moreover, Kardas erected a separate subspecies, *O. obesus antiquus*, for the fossil-subfossil forms, based in part on specimens dredged up from the continental shelf off New Jersey. The current view, as expressed by Ray et al. (1968), is that the Pacific and Atlantic populations constitute one monospecific genus.

The southernmost fossil record of *O. rosmarus* is from off of Cape Hatteras, North Carolina (Kurtén & Anderson, 1980). The walrus presently is found in shallow northern polar waters, around rocky coasts and on ice floes. Walruses will migrate

southward in the winter, floating on ice floes; this probably determines their southern limit, rather than the southern limit of pack ice as suggested by Kardas (1965). The walrus is a duraphagous bottom-feeder, excavating clams from the ocean-bottom substrate and using its thick lips, piston-like tongue, and bony palate to create a powerful suction that frees the clam from its shell, providing the walrus with a meal (Nelson & Johnson, 1986). It is a rich irony that the clam-eater's remains may help provide a favorable substrate for the setting and growth of bivalve spat.

Order Proboscidea
Family Mammutidae
Genus *Mammut*

Referred material: NJSM 14249; material on loan to NJSM from Barney's Dock site; ANSP 15847-15849, 15851, 15852 (all listed simply as "off the coast of New Jersey"), 15263 ("Wildwood"), 15149 ("Beach Haven Inlet, Ocean City, N.J." [sic]), 15274 ("off Atlantic City"), and an uncatalogued ANSP tooth identified as coming from "approximately 50 miles east of Atlantic City"; and USNM unnumbered (a molar dredged in 10 fathoms [18 m] of water off Brielle, New Jersey, by George Sires).

Whitmore et al. (1967) have adequately summarized the locations and depths of proboscidean teeth recovered from the Atlantic continental shelf off of eastern North America up until that date, citing 41 different shelf sites. Since then, clammers have continued to bring in teeth for identification; the Cape May clamming fleet repeatedly dredges up mastodon teeth from the continental shelf in the vicinity of Assateague Island, Maryland, and Chincoteague, Virginia.

The mastodon tooth from the Barney's Dock site (Figure 1) is interesting because it displays a pair of twisted impacted roots. This tooth is a left mandibular, probably a deciduous premolar. Another mastodon tooth recently dredged up is NJSM 14249, found and donated by Ernest Carafa. This specimen is a large molar, a permanent M3 from the maxilla; it is missing the roots, a common condition for shelf mastodon teeth. It is from a site off the southern end of Long Beach Island, just north of the wreck of the *Algonquin* at the intersection of Loran lines 26850 and 4320, in water about 27 m (90 ft) deep.

While mastodon teeth are relatively common, other materials are rarely seen. This, along with its pathological aspect, is what makes the mastodon jaw from the Barney's Dock site so interesting. The tusk opening in the anterior tip of this right lower jaw section indicates that this was a subadult male (Kurtén & Anderson, 1980). The interior surface of the jaw is excavated by a large abcess cavity. The abcess lasted a long time, probably causing some pain and perhaps costing the animal its life. The abcess connected with the molars and may have caused their premature shedding; malocclusion began on the lateral (buccal) side and penetrated medially (lingually) (H. E. Lippman, personal communication).

All cited material is assigned to *M. americanum* (Kerr), the only Pleistocene species in North America. It is found throughout North America from Alaska to Florida and ranges in age from the Blancan (Pliocene) to early Holocene time (extinction phase from 12,000 to 9,000 yr B.P.). The American mastodon apparently preferred spruce forests, open woodland, valleys, lowlands, and swamps (Kurtén & Anderson, 1980). Numerous samples of marsh peat, both freshwater and salt, have been dredged up from various depths on the continental shelf (Whitmore et al., 1967) as well as petrified wood assigned a Pleistocene age dredged up from 27 m (90 ft) deep 30 miles southeast of Cape May (Richards, 1960). Thus there was vegetation of the right sort available, indicating that lowland swamp, marsh, and coniferous forest environments extended across the exposed continental shelf during times of glacially-lowered sea level. Radiocarbon dates on the now-submerged peats reveal a cluster of dates (see Whitmore et al., 1967, fig. 2) that agrees quite closely with the time span for the extinction of *M. americanum* (Kurtén & Anderson, 1980). Dr. H. E. Lippman, who is currently studying mastodon cranial osteology, has expressed the opinion (personal communication) that many of the dental pathologies observed in late Wisconsinan mastodon specimens (such as those from the Barney's Dock site) may have resulted from having to eat food that *M. americanum* was not adapted to consume. Perhaps changes in climate and sea level at the end of the last Pleistocene glaciation put habitat pressures on the mastodon population.

Family Elephantidae
Genus *Mammuthus*

Referred material: NJSM 12723; ANSP 16467, 16468.

Whitmore et al. (1967) have already listed locality data for many proboscidean teeth from the continental shelf. Two of the teeth cited in that study as unnumbered specimens in the collection of the Academy of Natural Sciences have now been assigned catalogue numbers ANSP 16467 and 16468. They were donated by Mrs. S. Osmundsen and are identified as coming from "off the coast of Cape May."

A specimen recently added to the collection of the New Jersey State Museum demonstrates another important mode of discovery of Pleistocene fossils. NJSM 12723 was found at Beach Haven Inlet in Ocean Township, Ocean County, on a sandbar after a major Atlantic storm. This mammoth tooth was collected and donated by Robert Tyrell. Other Pleistocene mammal specimens have been found as beach wash along the coast, and fossil shark teeth of Neogene age are sometimes encountered on the southern New Jersey beaches (Gallagher, 1984).

Because of the difficulties discussed by Whitmore et al. (1967), these specimens are best designated simply as *Mammuthus* sp. The continental shelf mammoth teeth seem to represent a unique population, perhaps a dwarf race of *M. primigenius* or *M. jeffersoni* (see Whitmore et al., 1967); this dental anomaly is reminiscent of the abnormalities seen in many shelf mastodon specimens, and may be attributable to the same habitat stresses imposed during the change in climate and sea level at the end of the Pleistocene.

Order Perissodactyla
Family Equidae
Genus *Equus*

Referred material: uncatalogued ANSP specimen.

While Richards (1959) included the horse in his list of Pleistocene mammals from the continental shelf, Parris (1983) has noted the problems with previous identifications of equid material from New Jersey. Although Richards (1957, 1959) did not cite specimen numbers, perhaps he had in mind the uncatalogued ANSP horse jaw found as beach wash at Long Beach Island. Large mammal bones are frequently found on the beach after storms; many of those which have been brought to our attention are domestic cattle bones, probably washed up on the beach from some offshore charnel dump. Thus it is advisable to exercise caution in assigning a Pleistocene age to extant species whose remains are found on the shore, and we mention this record with such a note of caution.

Family Tapiridae
Genus *Tapirus*

Referred material: ANSP 15270.

This thoroughly permineralized partial right dentary is quite similar to the lower jaw of a modern tapir, but it is somewhat more robust. It was dredged up from the Atlantic Ocean 25 miles south-southeast of Cape May, New Jersey, and donated by J. Entriken (see Figure 2). The ANSP specimen is edentulous and thus identifiable only to genus. Richards (1957) mentions what may be a separate occurrence, a jaw dredged up from Five Fathom Bank off Cape May by Preston Hawk in 1956.

Tapir remains were the most abundant specimens found at the Port Kennedy cave deposit near Valley Forge, Pennsylvania (Cope, 1895). Savage & Russell (1983) have assigned an Irvingtonian age to this fauna, and Kurtén & Anderson (1980) believe the Port Kennedy assemblage more specifically represents an interglacial fauna.

Order Cetacea

Referred material: uncatalogued NJSM and ANSP specimens; and bones from the Barney's Dock site on loan to NJSM.

Along with the mastodon and walrus material, we have also received a number of cetacean bones from the Barney's Dock site. Some of the material is quite permineralized, dark gray in color and heavy, while other bones are light in color and weight. The specimens consist of a large centrum, rib fragments, and a broken skull fragment. Some of the bones, as noted above, are bored by pelecypods. Diagnostic material (such as mandible, rostrum, or teeth) is not represented, so it cannot be determined if these are odonticete or mysticete remains. A permineralized whale vertebra is also present in the continental shelf collection of the ANSP; this was dredged up off Cape May.

Additional material in the NJSM collection includes a mysticete humerus, donated by the Larson family, and a fragment of a large rib which because of its size is probably either mysticete or *Physeter*.

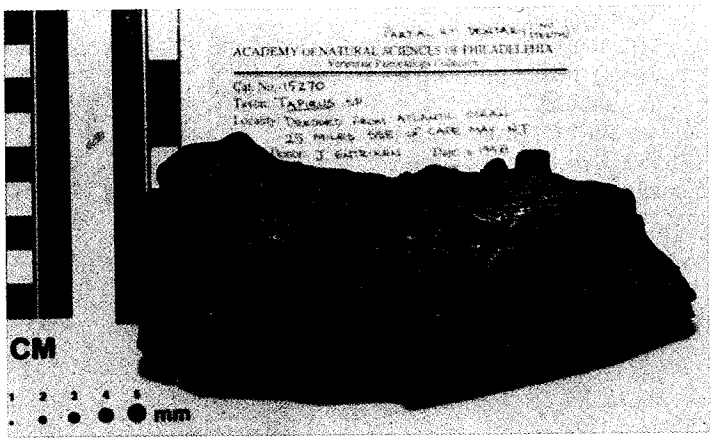

Figure 2. *Tapirus* sp., ANSP 15270, dentary.

Order Artiodactyla
Family Cervidae
Genus *Rangifer*

Referred material: NJSM 14248, and material on loan from the Barney's Dock site.

NJSM 14248 is the specimen whose discovery at the Barney's Dock site confirmed a prediction, as noted above. It is also the first record, so far as we can determine, of caribou from the continental shelf. The specimen is a portion of the right antler extending from the base to the palmation of the bez tine, with a fracture along a piece of the main beam at the first branching; the fragment is 31 cm (1 ft) long (Figure 3). It is referred to *R. tarandus* which is also known from onshore sites at Vincentown and Big Brook (Parris, 1983). This specimen was generously donated to NJSM by the crew of the *Amanda Sue*. A further prediction was made that if caribou ranged out into the continental shelf during times of glacio-eustatically lowered sea level, one would expect that there are more caribou bones and shed antlers awaiting discovery on the shelf since caribou congregate in large herds. This prediction was confirmed on 3 March 1988 when Roger Cranmer of Barney's Dock donated a recently dredged specimen of antler to the NJSM (Figure 4). This antler section is longer (79 cm on the outside curvature) and more spindly than the first specimen. It is a portion of a left caribou antler dredged from approximately 15 m (50 ft) of water 4.8 km (3 mi) east of Beach Haven Inlet.

Genus *Cervalces*

Referred material: PU 16342.

This right metacarpal of an extinct elk-moose was cited by Whitmore et al. (1967) as coming from the Hudson Canyon off New York from a depth of 160 m (525 ft); this specimen is

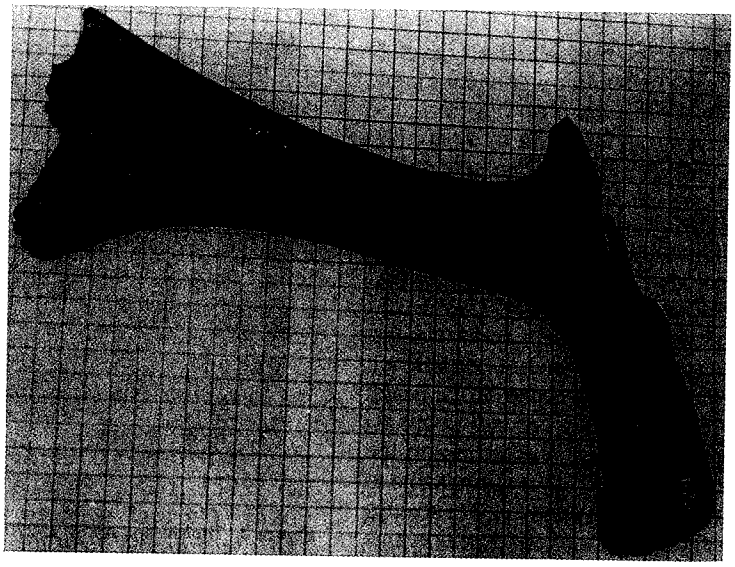

Figure 3. Portion of caribou (*Rangifer tarandus*) antler, NJSM 14248, from the Barney's Dock site.

figured here for the first time (Figure 5). Chucher & Pinsof (1988) gave radiocarbon dates for two nearby onshore specimens of 11,230 +/- 160 yr B.P. (Columbia, New Jersey, specimen) and 10,950 +/- 150 yr B.P. (Middletown, New York, specimen); these dates are well within the range of radiocarbon dates given by Whitmore et al. (1967) for continental shelf peat deposits and relict oyster shells.

Family Bovidae
Genus *Symbos*

Referred material: PU 16340.

The horn core and left frontal of an extinct musk-ox, *S. cavifrons*, was dredged up in 60 m (197 ft) of water 64 km (40 mi) southeast of Atlantic City (Whitmore et al., 1967). This specimen was figured by Parris (1983, fig. 4). *S. cavifrons* differed from the modern musk-ox in being taller and more slender; it probably inhabited plains and woodlands from late Irvingtonian time to the end of the Wisconsinan glaciation (Kurten & Anderson, 1980).

Genus *Bison*

Referred material: ANSP 15862.

This specimen is the broken end of the distal humerus of a bovid not distinguishable from a bison. The only locality data given in the ANSP catalogue and on the specimen label are simply, "Dredged from Atlantic." We tentatively assign this specimen to *Bison* sp.; if this is correct, then it is the first occurrence of bison from the continental shelf.

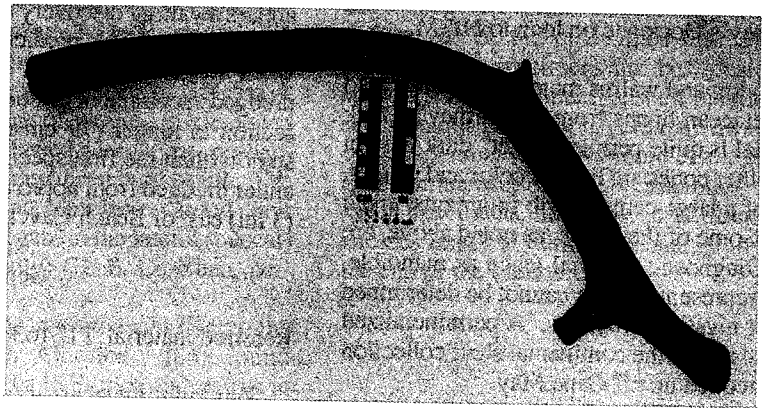

Figure 4. Portion of *Rangifer tarandus* antler, NJSM 14732.

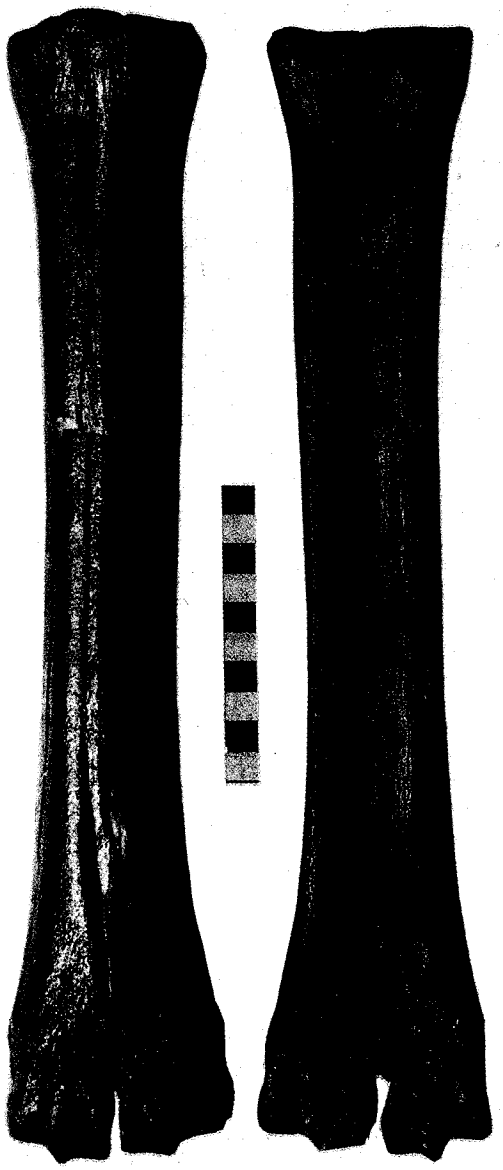

Figure 5. *Cervalces scotti*, right metacarpal, Princeton University specimen from Hudson Canyon, PU 16342.

Order Sirenia
Family Manatidae
Genus *Trichechus*

Referred material: ANSP 15860.

Originally identified as *O. rosmarus*, this specimen was recognized as a sirenian by B. Grandstaff. It possesses the dense interior bone structure typical of sirenian material, and agrees in morphology with the fused radius and ulna figured by Kaiser (1974) (Figure 6). The ANSP label simply identifies its provenance as "Dredged off New Jersey coast." This specimen has been confirmed by D. P. Domning as the northernmost known occurrence of manatee; Kurtén & Anderson (1980) reported its northern Pleistocene limit in North Carolina. At present, manatees are found primarily in Florida; they are extremely temperature-sensitive and during cold spells will seek out warm inland springs and the outfalls of power plants in order to survive.

Order Xenarthra
Family Megalonychidae
Genus *Megalonyx*

Referred material: USNM 25175.

The proximal half of the left radius of a ground sloth was collected by Ronald Stires of the fishing trawler *Kingfisher* at 40°16.5' N., 73°54.5' W. in 19 m (62 ft) of water off Sandy Hook, New Jersey. Like the tapir jaw and the manatee material mentioned above, this specimen is not consistent with the predominantly glacial phase aspect of the majority of the shelf specimens from this region. Parris (1983) summarized the onshore occurrences of *Megalonyx* in New Jersey and noted the beach-washed calcaneum of *Eremotherium mirabile* (Leidy) found at Long Beach, New Jersey, described by Hay (1923). USNM 25175 was recognized by H. Gregory McDonald and Clayton E. Ray, and is more completely described by them in a paper now in preparation.

Taphonomic Discussion

There is an obvious disparity in the above-mentioned fauna; it consists of a mixture of terrestrial forms with marine animal remains. The fossils and subfossils are essentially co-occurring on the surface of the continental shelf, since, as noted above, the bite of a clamming dredge penetrates only several inches into the shelf substratum. Some of the specimens from the Barney's Dock site are quite permineralized and dark, while other remains (primarily the cetacean bones) are light in color and weight.

It is well known that the continental shelf was largely exposed land during the Wisconsinan glacial maximum, and that the shoreline has moved more or less continuously toward its present position since ice-cap meltback commenced some 12,000 to 15,000 yr ago (see, for example, the numerous references in

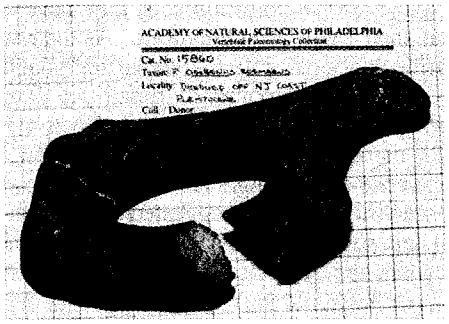

Figure 6. *Trichechus* sp., ANSP 15860; originally misidentified at *Obobenus rosmarus*. Fused radius and ulna.

Table 1.
Continental Shelf Quaternary Mammal Fauna

Carnivora
- Phocid indet. - seal
- *Odobenus rosmarus* - walrus

Proboscidea
- *Mammut americanum* - mastodon
- *Mammuthus* sp. - mammoth

Perissodactyla
- *?Equus* sp. - horse
- *Tapirus* sp. - tapir

Cetacea
- Mysticete indet. - baleen whale
- Odontocete indet. - toothed whale

Artiodactyla
- *Rangifer tarandus* - caribou
- *Cervalces scotti* - elk
- *Symbos cavafrons* - musk ox
- *Bison* sp. - buffalo

Sirenia
- *Trichechus* sp. - manatee

Xenarthra
- *Megalonyx* sp. - giant ground sloth

Richards et al., 1986). Indications from sea-level rise curves (such as those presented in Colquhoun, 1982) suggest that the initial flooding was more rapid and inundation of the shelf has slowed as the Holocene progressed. This transgressive event, known as the Flandrian transgression, moved the shoreline increasingly westward; a complex of environments migrated across the shelf in response to this sea-level rise. Where mastodon had previously trod, new coastline and newly submerged shallows provided a habitat for walrus. Later, as water deepened, whales could add their bones to the accumulation.

There may have been an additional factor involved in the accumulation of large Quaternary mammals on the bottom of the continental shelf. Bones stored in peat deposits or marsh muds (a common mode of occurrence for Pleistocene megafauna fossils; see Jepsen, 1964), in river bank and channel deposits, and in estuarine and lagoonal environments, may have contributed to continental shelf fossil accumulations. As the river and bay mouth/estuarine lagoonal salt marsh/barrier island complex retreated westward in response to rising sea level, intense reworking could be accomplished by storm activity along the coastline with its concomitant flooding, peak flow, and high-energy competence in moving such large clasts as bones and teeth. This scenario has been suggested for mixed terrestrial-marine fossil deposits of Late Cretaceous and Miocene-Pliocene ages, times when the Atlantic Coastal Plain was undergoing transgression (Gallagher & Parris, 1986; Gallagher et al., 1986).

Bone material from these deposits also displays the activities of marine boring bivalves. Associations of marine mollusks within bone are well known in the fossil record (Gallagher et al., 1986; Parris et al., 1987). It is possible that some pelecypod fossil concentrations are due to what Kidwell & Jablonski (1983) have called taphonomic feedback: the adaptation of an organism to a fossil or subfossil substrate, utilizing the remains of previously existent organisms as ecospace. The association of both land and marine vertebrates with marine invertebrates may provide us with some idea of the dynamics that were involved in producing these mixed faunal assemblages.

Moreover, a modern analogue for this type of accumulation exists. Frey et al. (1975) have reported on the accumulation of marine and terrestrial fossils of Miocene and Pleistocene ages in estuaries along the Georgia seacoast. Estuarine peats and relict oyster shells (*Crassostrea virginica* prefers brackish water) are known to exist on the continental shelf bottom; perhaps estuarine deposits are the source of some of the shelf mammal fossils.

Conclusions

Our experience with the Barney's Dock site leads us to conclude that the fossil resources of the continental shelf are an under-utilized source of valuable data that can conceivably offer us insights into the taphonomy of mixed fossil occurrences, climate change and sea level fluctuations, and perhaps even the question of why the Pleistocene megafauna became extinct.

Table 1 summarizes the currently known mammalian fauna of Quaternary age from the continental shelf. With the exceptions of the tapir, ground sloth, and manatee (three isolated occurrences), this is primarily a boreal- or glacial-stage fauna, the terrestrial forms representing the mammals that occupied the exposed shelf region at the end of the Wisconsinan glaciation and into the early part of the Holocene. Rapidly changing climatic conditions flooded a large part of the shelf range of these animals in a relatively short period of time (perhaps only several thousand years) and also led to a situation of coevolutionary disequilibrium in which previously abundant preferred trophic resources became scarce. The known dates for this habitat-shrinking coincide quite nicely with the spread of a new arrival from the west, *Homo sapiens*; the shelf populations of large terrestrial mammals may have felt pressure on their landward flank from this newcomer.

Figure 7 represents a map tabulation of all known Pleistocene mammal sites in New Jersey and the continental shelf off New Jersey. Some striking linearities are apparent, particularly along the trend of the Hudson Canyon. These linear site trends may be due to the kinds of taphonomic phenomena discussed above. We feel that it is imperative, when considering the origin of the shelf fossils or of other, similar assemblages, to keep in mind the well-established eustatic history of the area and the migratory nature of its depositional environments. Instead of a static, transgressive lag model in which bones lie where they died as the sediment around them is moved, we prefer a dynamic model of fossil mixing and movement for these mixed terrestrial-marine faunas. Such a model is more in keeping with modern concepts of taphonomy and coastal geological processes.

We are in the process of distributing flyers to the shellfish fleets along the New Jersey coast in cooperation with the state licensing agencies. We hope to establish more data points and co-occurrences with accurate reporting of depths and precise locations. The continental shelf specimens can tell us some in-

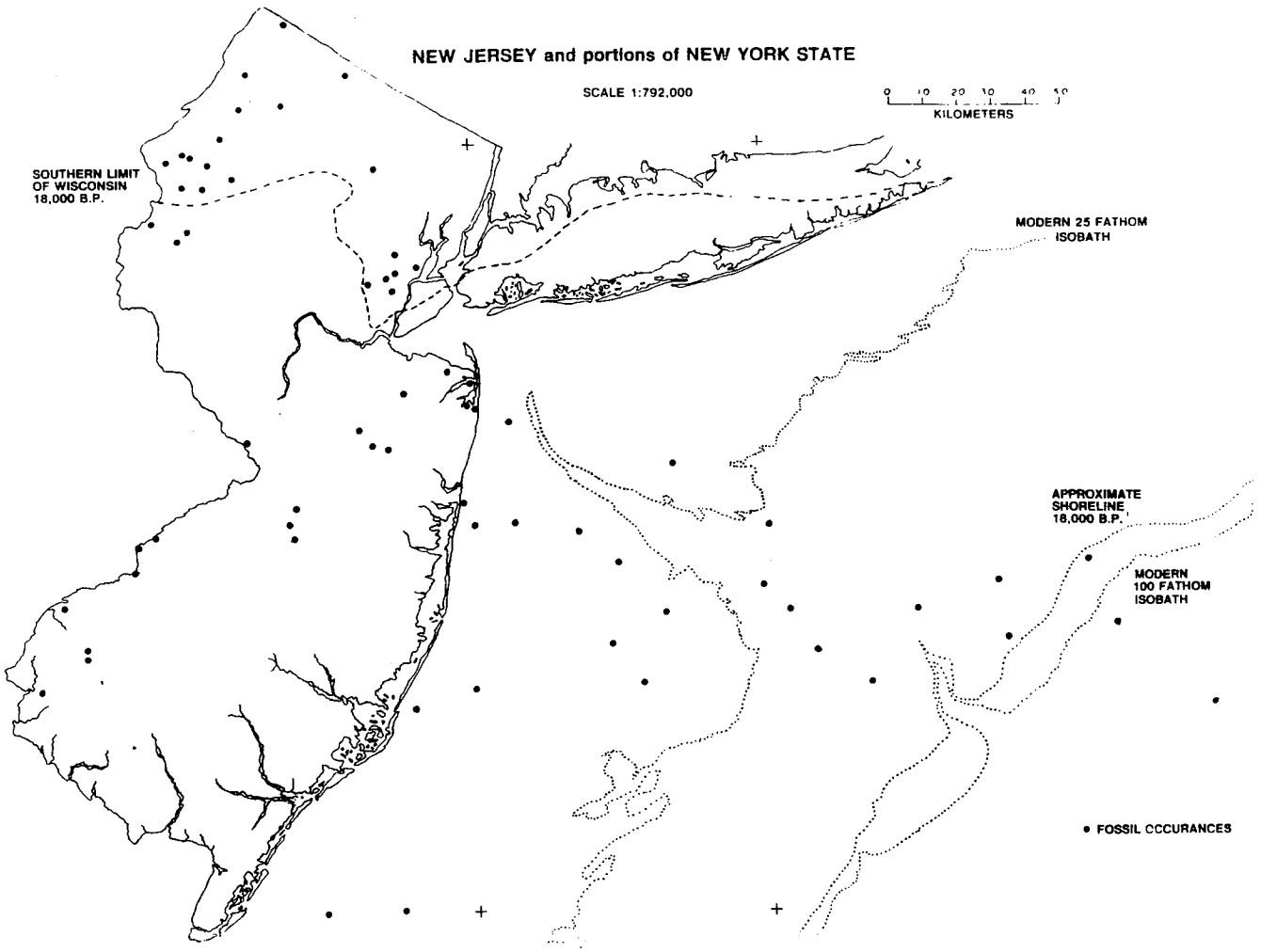
NEW JERSEY and portions of NEW YORK STATE
SCALE 1:792,000
0 10 20 30 40 50
KILOMETERS
SOUTHERN LIMIT OF WISCONSIN 18,000 B.P.
MODERN 25 FATHOM ISOBATH
APPROXIMATE SHORELINE 18,000 B.P.
MODERN 100 FATHOM ISOBATH
• FOSSIL OCCURANCES

Figure 7. Map of known Pleistocene mammal occurrences in New Jersey and on continental shelf off New Jersey. Dashed line indicates southern limit of Wisconsin glaciation.

teresting things specifically about the Pleistocene fauna and more generally about the origin of some kinds of fossil accumulations.

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